

ON THE  
IRON ORES OF CARNARVONSHIRE.

BY THE  
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## IRON ORES OF CARNARVONSHIRE.

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HAVING had an opportunity recently of examining and analyzing the principal iron ores of Carnarvon, I thought that the results would be of some interest to the Geological Society of Dublin. I have therefore prepared a short abstract of the results of my observations.

1. The first quarry of iron ore examined by me is situated near Bettws Garmon, on the road from Carnarvon to Beddgelert. It is worked by the Aberdare Iron Company, and the iron ore extracted from it is shipped to South Wales, to be mixed with the clay iron-stones, which are not so rich in per-centage of iron. The ore is of a dark-green colour, oolitic texture, and is magnetic. The iron occurs in it in the form of protoxide and peroxide; some of the former being combined with the latter as magnetic oxide, and some being combined with carbonic acid. This ore is found stratified conformably to the bedding of the black slates in which it occurs. It is found in a single bed of a thickness varying from 25 to 32 feet; strike bearing E.  $50^{\circ}$  N. and dip  $50^{\circ}$  S. E. The outcrop of the bed is parallel to the line of junction of the black slates and roofing slates, this junction being somewhat less than half a mile distant to the N. W.

Its geological position is therefore the lower portion of the lingula beds, and I believe no fossils have been found beneath it.

The following analysis, made by Dr. Price, of Newport, will give a better idea than a long description of the exact nature of this interesting ore.

1. *Oolitic Magnetic Iron Ore, Careg Fawr.*

Loss by ignition (being Carbonic Acid, Organic Matter, &c.),	7.90
Clay and Silica, . . . . .	12.90
Peroxide of Iron, . . . . .	34.14
Protoxide of Iron, . . . . .	32.90
Alumina, . . . . .	3.66
Lime, . . . . .	5.00
Magnesia, . . . . .	1.00
Phosphoric Acid, . . . . .	2.25
Sulphur, . . . . .	0.25
Arsenic, . . . . .	Trace.
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	100.00

The quantity of metallic iron is 49.50 per cent. in the raw ore, and 53.74 per cent. in the roasted.

2. A bed of iron ore, resembling that just described, occurs on the west coast beyond Clynnog, near Morfa, at the foot of Yr Eifl. It is, however, composed of coarser globules, and might be described as pisolitic rather than oolitic. It is also of a redder colour, and more variable composition; the most remarkable difference occurring in the quantity of phosphoric acid, which is so very great in some specimens as to warrant the inference that it occurs in nodules irregularly distributed.

The following Table gives the results of trials made on seven specimens:--

*Pisolitic Iron Ore, Llanaelhaiarn.*

	1	2	3	4	5	6	7
Loss by ignition,	19.23	14.00	. . .	17.89			
Clay and Silica,	. . .	. . .	14.72	11.28			
Peroxide of Iron,	. . .	. . .	*55.34	25.29			
Protoxide of Iron,	. . .	. . .	. . .	33.24	11.13		
Alumina, . . .	. . .	. . .	†4.83	†7.09			
Lime, . . .	. . .	. . .	‡1.85				
Magnesia, . . .	. . .	. . .	Trace.				
Phosphoric Acid,	. . .	. . .	. . .	. . .	. . .	10.38	1.32

\* Including phosphoric acid, &c., and without separating protoxide of iron.

† Including phosphoric acid.

‡ Not in combination with phosphoric acid.

The average composition of this ore would therefore be:—

2. *Pisolitic Magnetic Iron Ore, Llanaelhaiarn.*

Loss by ignition, . . . . .	18·61
Clay and Silica, . . . . .	13·00
Peroxide of Iron, . . . . .	25·29
Protoxide of Iron, . . . . .	33·24
Alumina, . . . . .	*7·09
Lime, . . . . .	1·85
Phosphoric Acid, . . . . .	1·32
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	100·40

This gives of metallic iron 43·55 per cent. in the raw ore, and 53·50 per cent. in the roasted.

The bed in which this pisolitic magnetic iron ore occurs has an average width of 18 feet, and is conformable to the bedding of the black slate in which it lies, its strike bearing E. 35° N. and dip 80° N.

Besides the pisolitic ore just described, two other varieties occur in the same bed,—the first being found near the walls of the lode, and the other appearing to constitute large nodules of a fine oolitic texture and reddish colour.

3. *Black Slaty Iron Ore, Llanaelhaiarn.*

Loss by ignition (being Organic Matter and Water), . .	8·13
Clay and Silica, . . . . .	38·79
† Peroxide of Iron, . . . . .	40·34
Alumina, . . . . .	12·55
Lime, . . . . .	Trace.
Magnesia, . . . . .	0·31
Phosphoric Acid, . . . . .	0·07
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	100·19

4. *Kidney Iron Ore, Llanaelhaiarn.*

Loss by ignition, . . . . .	28·03
Clay and Silica, . . . . .	2·62
Peroxide of Iron, . . . . .	5·92
Protoxide of Iron, . . . . .	49·92
Alumina, . . . . .	3·12
Lime, . . . . .	5·87
Magnesia, . . . . .	Trace.
Phosphoric Acid, . . . . .	4·45
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	99·93

Metallic iron = 42·95 per cent. in the raw ore, and = 59·66 per cent. in the roasted ore.

\* Containing some phosphoric acid.

† Protoxide included.



This kidney ore contains a much larger proportion of protoxide than usual, and appears to be simply a nodule of spathose ore, with a considerable quantity of phosphoric acid. The different parts of the lode are very variably magnetic, according as the magnetic oxide or spathose iron predominates.

3. Several beds of magnetic oolitic iron ore occur about a mile beyond Abersoch, St. Tudwal's Road,—the ore resembles in many respects the oolitic ore of Careg Fawr, but occasionally passes into a reddish coarse-grained ore, resembling some of the varieties from Llanaelhaiarn. These beds conform to the bedding of the slate in Mr. Homfrey's mine, where they have a strike of E. 25° N. dip 60° N., and average width of 25 feet. Two or three of these beds are exposed in this quarry, one of them containing a large "horse" or nodule of shale in the centre of the iron ore.

The beds of black slate are very much disturbed in this locality, and the beds of iron ore appear to have been broken and twisted with the slates in which they occur.

At Holland's quarry, at Vron, the strike is N. 60° E.; dip S. E. nearly vertical, and width of bed, 18 feet.

The average strike in the Abersoch district is between E. 2° N. and E. 70° N.

The following analysis shows the composition of the black oolitic variety of ore.

*5. Black Oolitic Iron Ore, Abersoch.*

	1	2	3	Average Comp.
Loss by ignition, .	19·01	18·97	. . . .	18·99
Clay and Silica, .	22·49	22·57	22·78	22·61
Peroxide of Iron, .	. . . .	. . . .	4·04	4·04
Protoxide of Iron, .	. . . .	. . . .	44·01	44·01
Alumina, . . . .	. . . .	*9·13	*7·60	5·74
Lime, . . . .	. . . .	1·57	. . . .	1·57
Magnesia, . . . .	. . . .	1·21	. . . .	1·21
Phosphoric Acid, .	1·86	. . . .	. . . .	1·86
				100·03

Giving of metallic iron 37·06 per cent. in the raw ore, and 45·75 per cent. in the roasted ore.

\* Including phosphoric acid.

The large quantity of phosphoric acid occurring in these ores diminishes their market value, as it injures the iron produced from them. How to account for the phosphoric acid is a difficult question, and in expressing my own opinion that it is due to organic remains, such as coprolites, &c., I merely offer a conjecture to account for the presence of the phosphoric acid by known causes. If this be the true origin of the phosphoric acid, its occurrence is very interesting, as the geological position of the beds of ore is below the oldest beds in which fossils have hitherto been found.

Another very interesting question suggests itself from the examination of the facts described,—Are these deposits of iron ore lodes or beds? They appear to conform accurately to the bedding of the slate at Careg Fawr, for a distance of more than three-quarters of a mile; and at Llanaelhaiarn and Abersoch there is no possibility of detecting any deviation from the bedding of the black slates. If, therefore, they are lodes, they must have been formed in fissures, made along the planes of mechanical deposition of the black slates; but this appears to me so improbable that I prefer considering them as beds formed by chemical action at the time of deposition of the slates in which they are found. All the deposits of iron ore occur in the same geological horizon, and there must have been some very unusual combination of causes to produce simultaneously over so great an area the large amount of iron ore which we now find there.

The mode in which these deposits occur is very similar to the mode of occurrence of the pyrites courses of Ballymurtagh, which have been generally considered as deposited conformably to and simultaneously with the slates in which they occur; and it must be confessed that there is some difficulty in supposing the fissuring of beds in the direction of their bedding. But it is possible, as Mr. Warrington Smyth has endeavoured to show in the Ovoca mines, that there may be a tendency to cut very obliquely across the line of strike, and that the conformability may be only true within a certain distance.

The short depth to which the ironstone beds have been worked in Carnarvonshire renders it difficult to determine this point with certainty.

